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Europäisches Patentamt  
European Patent Office  
Office européen des brevets

Publication number:

**0 161 697  
A1**

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## EUROPEAN PATENT APPLICATION

21 Application number: 85200459.7

51 Int. Cl.<sup>4</sup>: **C 09 D 3/48**, C 08 G 85/00,  
C 08 G 61/12, C 08 F 283/00

22 Date of filing: 27.03.85

30 Priority: 29.03.84 NL 8401007

71 Applicant: **AKZO N.V.**, Velperweg 76, NL-6824 BM  
Arnhem (NL)

43 Date of publication of application: 21.11.85  
Bulletin 85/47

72 Inventor: **Akkerman, Jaap Michiel**, Zijlweg 328,  
NL-2105 CP Haarlem (NL)

84 Designated Contracting States: **AT BE CH DE FR GB IT  
LI NL SE**

74 Representative: **Sieders, René et al**, P.O. Box 314,  
NL-6800 AH Arnhem (NL)

54 Liquid coating composition curable at ambient temperature.

57 The invention provides a liquid coating composition curable at ambient temperature based on an  $\alpha,\beta$ -ethylenically unsaturated carbonyl compound and a particular compound with an activated CH group such as a malonic oligomer or polymer.

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Liquid coating composition curable at ambient temperature.

The invention relates to a liquid coating composition based on a compound containing an activated CH group and an  $\alpha,\beta$ -ethylenically unsaturated carbonyl compound.

5 A coating composition of the type indicated above is known from, int.al. German Patent Specification no. 835 809. As compounds containing an activated CH group it proposes acetoacetates, acetoacetamides and cyanoacetates.

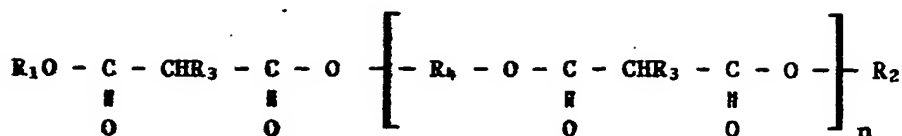
10 Examples of suitable  $\alpha, \beta$ -ethylenically unsaturated carbonyl compounds include acrylic or methacrylic esters or amides. In practice, however, it has been found that these well-known compositions can generally be insufficiently cured at room temperature and special steps must therefore be taken for the object coated with such a composition to be heated to the elevated temperature desired. This is a drawback particularly in the case  
15 of, for instance, large steel structures.

It should be noted that also a coating composition based on an epoxy resin to be cured with a polyamine is curable at room temperature, however, the resulting coatings display insufficient stability of gloss upon outdoor exposure.

20 Further, compositions based on a polyisocyanate and a suitable hydroxy compound also cure at room temperature, although polyisocyanates may impair health and can therefore be used only when taking some special precautions.

25 The present invention provides compositions that can be used without taking special safety precautions and can very well be cured at ambient or even lower temperatures and result in coatings that display favourable properties, such as gloss retention, hardness and flexibility.

The coating composition according to the invention is characterized in that the compound containing an activated CH group is a compound of the  
30 formula



where  $R_1$ ,  $R_2$  and  $R_4$  are independently chosen organic radicals,  $R_3$  is an H atom, a group  $R_5$  or a group of the formula  $-CH_2 - CHR_6 - COOR_5$ ,  $R_5$  represents an alkyl group having 1-18 carbon atoms and  $R_6$  an H atom or a methyl group, and  $n$  is at least 1, which compound has a molecular weight in the range of from 250 to 50 000. The compound according to the invention containing an activated CH group is referred to hereinafter as malonate compound.

As examples of suitable oligomeric or polymeric malonate compounds may be mentioned polyurethanes, polyesters, polyacrylates, epoxy resins, polyamides or polyvinyl resins containing malonate groups either in the main chain or the side chain or in both.

Suitable malonate groups-containing polyurethanes may be obtained, for instance, by bringing a polyisocyanate into reaction with a hydroxyl group-containing ester of a polyol and malonic acid, by esterification or transesterification of a hydroxyfunctional polyurethane with malonic and or a dialkyl malonate. Examples of suitable polyisocyanates include hexamethylene diisocyanate, isophoron diisocyanate, toluene diisocyanate and addition products of a polyol to a diisocyanate, such as that of trimethylol propane to hexamethylene diisocyanate, isocyanurates obtained from 3 molecules of diisocyanate such as hexamethylene diisocyanate or isophoron diisocyanate, and biurets obtained from 3 molecules of diisocyanate such as hexamethylene diisocyanate and 1 molecule of water.

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Examples of suitable hydroxyfunctional polyurethanes include the addition products of a polyisocyanate to di- or polyvalent hydroxy compounds such as neopentyl glycol, dimethylol cyclohexane, trimethylol propane, 1,6-hexane diol and polyether polyols, polyester polyols or polyacrylate polyols.

Suitable malonic polyesters may be obtained for instance by polycondensation of malonic acid, an alkyl malonic acid, such as ethyl malonic acid, a mono- or dialkyl ester of such a carboxylic acid, or the reaction product of a malonic ester and an alkyl (meth)acrylate, optionally mixed with other di- or polycarboxylic acids, with one or more di- and/or higher functional hydroxy compounds, in combination or not with monofunctional hydroxy compounds and/or carboxyl compounds. As examples of suitable polyhydroxy compounds may be mentioned compounds containing 2-6 hydroxyl groups and 2-20 carbon atoms, such as ethylene glycol, diethylene glycol, propylene glycol, trimethylol ethane, trimethylol propane, glycerol, pentaerythritol and sorbitol.

Suitable malonate groups-containing polymers also may be prepared by transesterification of an excess of dialkyl malonate with a hydroxy functional polymer such as a vinyl alcohol-styrene copolymer. In this way polymers with malonate groups in the side chains are formed. After the reaction the excess of dialkyl malonate may optionally be removed under reduced pressure or be used as reactive solvent.

Suitable malonic epoxy esters may be prepared by esterifying an epoxy resin with malonic acid or a malonic monoester, or by transesterifying with a dialkyl malonate, optionally in the presence of one or more other carboxylic acids or derivatives thereof.

Suitable polyamides may be obtained in the same manner as polyesters, at least part of the hydroxy compound(s) being replaced with a mono- or polyvalent primary and/or secondary amine, such as cyclohexylamine, ethylene diamine, isophoron diamine, hexamethylene diamine or diethylene triamine. The above-envisaged reactions are perfectly known to a man skilled in the art and need not be further described here.

Preferably applied malonate compounds are malonate group-containing oligomeric esters, polyesters, polyurethanes or epoxy esters having 2-100, preferably 2-20 malonate groups per molecule. It is preferred that the malonate compounds should have a number average molecular weight in the range

f from 250 to 30 000 and an acid number not higher than 5, preferably not higher than 2. Use may optionally be made of malonate compounds in which the malonic acid structural unit is cyclized by formaldehyde, acetaldehyde, acetone or cyclohexanone.

- 5 The  $\alpha,\beta$ -ethylenically unsaturated carbonyl compound to be used as second component may generally be any ethylenically unsaturated compound of which a double C-C bond is activated by a carbonyl group in the  $\alpha$ -position. As an example of a representative group of compounds may be mentioned the acrylic or methacrylic esters of hydroxyl compounds having 1-6 OH groups and 1-20 carbon atoms. The esters may optionally contain hydroxyl groups.
- 10 Examples of suitable esters include hexane diol diacrylate, trimethylol propane triacrylate and pentaerythritol triacrylate. Instead of or in addition to (meth)acrylic acid there may be used, for example: crotonic acid, or cinnamic acid. As an example of another
- 15 group of compounds may be mentioned the polyesters based on maleic acid or the anhydride thereof, fumaric acid and/or itaconic acid, and a di- or polyvalent hydroxyl compound, and optionally a monovalent hydroxyl and/or carboxyl compound. Other suitable groups of compounds are acrylic acid groups- and/or methacrylic acid groups-containing polyester resins or
- 20 alkyd resins. Examples of other suitable compounds include urethane (meth)acrylates obtained by reaction of a polyisocyanate with a free hydroxyl group-containing (meth)acrylic ester obtained by, for instance, esterification of a polyhydroxy compound with a less than stoichiometric amount of (meth)acrylic acid; polyether (meth)acrylates obtained by esterification of a hydroxyl groups-containing polyether with (meth)acrylic acid;
- 25 polyfunctional (meth)acrylates obtained by reaction of a hydroxyalkyl (meth)acrylate with a dicarboxylic acid, with a glycidyl groups-containing compound or with an amino resin; poly(meth)acrylates obtained by reaction of (meth)acrylic acid or the anhydride thereof with an epoxy resin; the
- 30 products obtained by reaction of a polycaprolactondi- or polyol with a polyisocyanate and with a hydroxyalkyl (meth)acrylate. All these types of compounds are known to a man skilled in the art and need not be further described here. It is preferred that use should be made of an acrylic acid group- or methacrylic acid group- containing polyol ester, polyurethane,
- 35 polyacrylate or amino resin having a functionality of 2-10 and an acid number not higher than 1.

The two afore-described components react with each through a so-called

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Michael addition, in which the malonate anion of the first component is added to one of the carbon atoms of the ethylenically unsaturated group of the second component. The two components are preferably contained in the composition in a ratio such that the ratio of the number of malonate groups of the first component to the number of double C-C bonds of the second component is in the range of from  $\frac{1}{2}$  to 4, preferably  $\frac{1}{2}$  to 2.

Although in the afore-going there is reference to separate malonate compounds and  $\alpha$ ,  $\beta$ -ethylenically unsaturated carbonyl compounds, the invention also permits the use of compounds with which the malonate group and the  $\alpha$ ,  $\beta$ -ethylenically unsaturated carbonyl structural unit are present in one compound.

An illustrative compound may be obtained, for instance, by treating a hydroxylic malonic polyester with, for instance, a diisocyanate of which an isocyanate group has already reacted with a hydroxyalkyl (meth)acrylate. For instance, the polyester may be brought into reaction with the adduct of 1 mole of isophoron diisocyanate and 1 mole of hydroxyethyl acrylate. The amounts of the starting compounds chosen are simply determinative of the ratio of malonate groups to the ethylenically unsaturated carbonyl groups.

The coating composition preferably also contains a catalyst for the reaction between the two afore-mentioned components or structural units. Suitable catalysts include electrically neutral bases such as amines and derivatives thereof. It is preferred that use should be made of a base of which the conjugated acid has a pKa of at least 12, such as amines of the amidine type, examples of which include tetramethyl guanidine, 1,4-dihydropyrimidines, 1,8-diaza-[5,4,0]-bicycloundecene and 2-alkyl-N-alkylimidazoline.

Amines such as triethylamine, dibutylamine, 1,4-diaza-[2,2,2]-bicyclooctane do not catalyse the cross-linking reaction until a temperature of about 150°C has been reached. Another class of suitable electrically neutral bases includes non-noble metals such as lithium, sodium or potassium.

According to the invention electrically charged bases also constitute suitable catalysts, provided that the conjugated acid thereof has a pKa of 5-45, preferably 9-19. As examples of representative bases may be mentioned metal bases and quaternary ammonium bases. Examples of suitable bases include metal oxides such as sodium methanolate; metal hydroxides

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such as potassium hydr xide; metal phenoxides such as sodium phenolat ; metal hydrocarbon compounds such as n-butyl lithium; metal hydrides such as sodium hydride; metal amides such as potassium amide; metal carbonates such as potassium carbonate; quaternary ammonium hydroxides such as tetra-  
5 butyl ammonium hydroxide; quaternary ammonium alkoxides such as benzyltrimethyl ammonium methoxide and quaternary ammonium carbanions such as benzyltrimethyl ammonium acetyl acetate.

The catalyst is generally contained in the composition in an amount of 0.1 to 10 equivalent per cent, preferably 1/2 to 5 equivalent per cent per  
10 equivalent malonate.

If desired, the action of the catalyst may be retarded or reduced by mixing it with a protic additive solvent having a pKa of 5-14, preferably 9-11, such as acetyl acetone, acetyl butyrolactone, ethyl acetoacetate or dimethyl malonate.

15 Optionally and depending on the field of application selected, the coating composition may contain one or more pigments, dyes and usual intermediary agents, additives and solvents. Examples of suitable inert organic solvents include ketones, esters, aromatic and aliphatic hydrocarbons; as examples of suitable reactive organic solvents may be mentioned dimethyl  
20 malonate, diethyl malonate and 2-ethylhexyl acrylate.

The coating composition may be applied to the substrate in any convenient manner, for instance by brushing, sprinkling, spraying or dipping. Suitable substrates are, for example, those of metals, wood, synthetic materials, paper or leather. Curing the coating applied can be effected in a  
25 very suitable manner at a temperature of, say, 0°-30°C. Optionally, use may be made of a curing temperature higher than 30°C, by which the curing time can be shortened.

#### Preparation of malonate resins

30 A. In a reactor a mixture of 495 parts by weight of 1,6-hexane diol, 503 parts by weight of dimethyl malonate and 2 parts by weight of dibutyltin oxid are heated, with stirring and under a stream of nitrogen, to a temperature of 105°C, increasing to 200°C. Following the addition of 20 parts by weight of hexane the remaining methanol was removed azeotropically. Subsequently, the temperature was decreased to 160°C and



167 parts by weight of xylene were added to the resin obtained, as a result of which a 79,4% by weight resin solution having a viscosity of 65 cPa sec. was obtained. The malonate resin A prepared had an acid number of 0,1, a hydroxyl number of 62, a number average molecular weight of 2450 and an equivalent weight of 250, calculated on the resin solution.

B. In a reactor a mixture of 392 parts by weight of dimethyl cyclohexane, 110 parts by weight of trimethylol propane, 297 parts by weight of dimethyl malonate, 199 parts by weight of dimethyl hexahydroterephthalate and 2 parts by weight of dibutyltin oxide was heated, with stirring and under a stream of nitrogen, to a temperature of 200°C. After 2 hours 90 ml of hexane were added slowly and the remaining methanol was removed azeotropically. Finally, the polycondensation mixture was subjected to vacuum distillation at 200°C. After cooling 339 parts by weight of xylene were added to the resin prepared, as a result of which a 69,0% by weight resin solution having a viscosity of 210 cPa sec was obtained. The malonate resin B prepared had an acid number of 0,23, a hydroxyl number of 110, a number average molecular weight of 2150 and an equivalent weight of 503, calculated on the resin solution.

C. In a reactor a mixture of 330 parts by weight of dimethyl malonate, 470 parts by weight of dimethylol cyclohexane, 35 parts by weight of trimethylol propane, 2 parts by weight of dibutyltin oxide and 33 parts by weight of xylene was heated, with stirring and under a stream of nitrogen, to a temperature of 200°C. After 2 hours 55 parts by weight of xylene were slowly added and the remaining methanol was distilled off in 2 hours. After cooling 173 parts by weight of 2-acetoxy-1-methoxy propane were added. Subsequently, 163 parts by weight of isophoron diisocyanate dissolved in 173 parts of xylene were added to the mixture over a period of 1 hour at 80°C, after which the reaction was continued for 1 hour at 100°C. After cooling a 66% by weight resin solution was obtained having a viscosity of 450 cPa sec. The malonate resin C obtained had an acid number of 0,22, and OH number of 65, a number average molecular weight of 2800 and an equivalent weight of 506, calculated on the resin solution.

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5 D. In a reactor a mixture of 194 parts by weight of dimethylol cyclo-  
hexane, 173 parts by weight of isophthalic acid, 109 parts by weight of  
trimethyl 1 propane, 2 parts by weight of dibutyltin oxide and 27 parts  
by weight of xylene was heated, with stirring and under nitrogen, to a  
10 temperature of 200°C. After 2 hours the mixture was cooled to 100° and  
229 parts by weight of isophoron diamine and 329 parts by weight of di-  
methyl malonate were added and the mixture was heated to a temperature  
of 200°C. After 2 hours 56 parts by weight of xylene were added slowly  
and the remaining methanol was distilled off in 2 hours. After cooling  
15 and subsequently adding 234 parts by weight of xylene and 234 parts by  
weight of 2-acetoxy-1-methoxy propane a 60%-resin solution was obtained  
having a viscosity of 510 cPa sec. The malonate resin D prepared had an  
acid number of 0,56, an OH number of 85, a number average molecular  
weight of 1500 and an equivalent weight of 540, calculated on the  
resin solution.

#### Examples

##### Example 1

20 A coating composition was prepared by successively mixing 10 parts by  
weight of the solution of malonate resin A, 2 parts by weight of n-  
butanol, 0,2 parts by weight of a 40% by weight solution of benzyltri-  
methyl ammonium methoxide and 4,2 parts by weight of trimethylol propane  
triacylate. The resulting composition was applied to a steel panel  
(Bonder No 120) in a coating thickness of 60 µm(after drying), after which  
the panel was kept at a temperature of 20°C. After 7 days the coating had  
25 a Persoz hardness of 40 seconds. The composition obtained had a gel time  
of 5 minutes.

##### Example 2

30 A coating composition was prepared by mixing successively 7,2 parts by  
weight of the solution of malonate resin A, 0,15 parts by weight of a 40%  
by weight solution in methanol of benzyltrimethyl ammonium methoxide and  
19 parts by weight of the adduct of 1 mole of isophoron diisocyanate and  
2 moles of hydroxypropyl acrylate. The resulting composition was applied  
to a steel panel (Bonder No 120) in a coating thickness of 60µm (after

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drying); after 2 hours at 18°C the coating had sufficiently cured (Persoz hardness f 70 seconds) and was resistant to solvents such as xylene and methylethyl keton . The resulting composition had a gel time of 8 minutes.

#### Example 3

- 5 A coating composition was prepared by mixing successively 0,5 parts by weight of acetyl acetone, 4,5 parts by weight of xylene, 0,1 part by weight of a 40% by weight solution in methanol of benzyltrimethyl ammonium methoxide, 15,9 parts by weight of the solution of malonate resin B and  
10 3,0 parts by weight of trimethylol propane triacrylate. The resulting composition, which had a gel time of 30 hours, was applied to a steel panel (Bonder 120) in a coating thickness of 60µm (after drying); after 7 days at a temperature of 20°C the coating had sufficiently cured (Persoz hardness of 80 seconds) and was resistant to xylene and methylethyl ketone.

#### Example 4

- 15 Example 3 was repeated, with the exception that the acetyl acetone and the benzyltrimethyl ammonium methoxide were collectively replaced by 0,22 parts by weight of tetramethyl guanidine. The composition, which had a gel time of 1 hour, gave a coating with identical properties.

#### Example 5

- 20 Example 4 was repeated, with the exception that the tetramethyl guanidine was replaced either by 0,16 parts by weight of 1,4-diaza-[2,2,2]-bicycloisooctane (DABCO) or by 0,16 parts by weight of dibutyl amine. The compositions prepared had a gel time of over 3 months and at a temperature of 180°C they gave sufficiently cured coatings resistant to methylethyl  
25 ketone.

#### Example 6

- A coating composition was prepared by mixing successively 0,6 parts by weight of acetyl acetone, 0,22 parts by weight of a 40% by weight solution in methanol of benzyltrimethyl ammonium methoxide, 4,9 parts by weight of  
30 xylene, 20,0 parts by weight of th resin solution C and 5,1 parts by weight of trimethylol propane triacrylate. The composition obtained was stable for 2 hours and was applied to a steel panel (Bonder 120) in a

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coating thickness of 60 $\mu$ m(after drying); after 7 days at a temperature of 20°C the coating had sufficiently cured (Persoz hardness of 70 seconds) and was resistant to xylene and methylethyl ketone.

Example 7

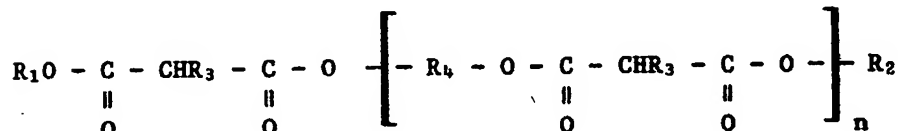
- 5 Example 6 was repeated, with the exception that the trimethylol propane triacrylate was replaced by 9,0 parts by weight of a 75%-solution of the addition product of 1 mole of isophoron diisocyanate to 2 moles of pentaerythritol triacrylate.

10 The coating composition was stable for 4 hours and was applied to a steel panel (Bonder 120) in a coating thickness of 60  $\mu$ m (after drying); after 7 days at a temperature of 20°C the coating had sufficiently cured (Persoz hardness of 200 seconds) and was resistant to xylene and methylethyl ketone.

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Claims

1. A liquid coating composition based on a compound with an activated CH group and an  $\alpha,\beta$ -ethylenically unsaturated carbonyl compound, characterized in that the compound with an activated CH group is a compound of the formula



where  $R_1, R_2$  and  $R_4$  are independently chosen organic radicals,  $R_3$  is an H atom, a group  $R_5$  or a group of the formula  $-\text{CH}_2-\text{CHR}_6-\text{COOR}_5$ ,  $R_5$  represents an alkyl group having 1-18 carbon atoms and  $R_6$  an H atom or a methyl group, and  $n$  is at least 1, which compound has a molecular weight in the range of from 250 to 50 000.

2. A coating composition according to claim 1, characterized in that the compound with an activated CH group is an oligomeric or polymeric malonate compound.
3. A coating composition according to claim 2, characterized in that the malonate compound is a polyurethane, a polyester, a polyacrylate, an epoxy resin, a polyamide or a polyvinyl resin with malonate groups in the main and/or side chain.
4. A coating composition according to claim 1, characterized in that the compound with an activated CH group is a malonate group-containing oligomeric ester, polyester, polymethane or epoxy-ester having 2-100 malonate groups per molecule.
5. A coating composition according to claim 1, characterized in that the compound with an activated CH group has a number average molecular weight of 250-30 000 and an acid number not higher than 5.

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6. A coating composition according to any one of the claims 1-5, characterized in that there is also present a catalyst for the reaction between the compound with an activated CH group and the  $\alpha$ ,  $\beta$ -ethylenically unsaturated carbonyl compound.
- 5 7. A coating composition according to claim 6, characterized in that the catalyst is an electrically neutral base of which the conjugated acid has a pKa of at least 12.
8. A coating composition according to claim 6, characterized in that the catalyst is an electrically charged base of which the conjugated acid  
10 has a pKa of 5-45.
9. A coating composition according to any one of the claims 6-8, characterized in that the catalyst is present in an amount of 0,1 to 10 equivalent per cent per equivalent of the compound with an activated CH group.



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# EUROPEAN SEARCH REPORT

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Application number

EP 85 20 0459

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
D,X	DE-A- 835 809 (BAYER) * Claim; page 2, left-hand column, lines 16-58 *	1,6-9	C 09 D 3/48 C 08 G 85/00 C 08 G 61/12 C 08 F 283/00
A	--- NL-A-7 502 288 (THE UPJOHN CO.) * Claims 1,29 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			C 08 F C 08 G
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 10-07-1985	Examiner DECOCKER L.
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